APPENDIX A

DESIGN OF TYPE III TANKS

Over the past 29 years, 51 tanks of four different basic designs have been built at the Savannah River Plant to store high-level nuclear wastes. Construction of these tanks is summarized in Table A-1; 27 of the tanks are of the most recent, or Tank III design, including the 14 tanks that are the subject of this environmental statement.

The Type III tank design was developed after an investigation of leaks from earlier Type I and Type II primary tanks. At the time of the investigation (1965), four primary tanks had leaked. Five more tanks have developed leaks since then, so leaks now affect five Type I and four Type II tanks. The conclusions of the investigation were that the primary leak-producing mechanism was stress corrosion cracking at sites in or near the weld seams and that stress relieving after fabrication should eliminate the cracking. For the Type III tanks, means were provided for heating each finished tank to relieve the stresses generated during fabrication. In addition, stress patterns were minimized by mounting the roof-supporting column on the foundation pad rather than on the bottom of the primary tank (as in Type I and II) and by providing an annular clearance around the roof-supporting column. Each Type III primary tank holds 1,300,000 gallons, is 85 ft in diameter, and is 33 ft high.

Structure

Each primary vessel of a Type III tank is made of two concentric carbon steel cylinders joined to washer-shaped top and bottom plates by curved knuckle plates (see Figure 3-3). Plate thicknesses are as follows:

Top and bottom	1/2 inch
Upper knuckle	1/2 inch
Outer wall	
Upper band	1/2 inch
Middle A band	5/8 inch
Middle B band	3/4 inch
Lower band	7/8 inch

TABLE A-1

High-Level Nuclear Waste Tanks at SRP

Number	Location	Type	Project Number	Construction Period	Type of Construction*
1-8	F	I	8980	1951-1953	Double wall - cooled
9-12	H	I	8980	1951-1953	Double wall - cooled
13-16	H	II	8980 P.W.O.	1955-1956	Double wall - cooled
17-20	F	IV	981031	1958	Single wall - uncooled
21-24	H	IV	981089	1962	Single wall - uncooled
25-28	F	III	951493 (75-1-a)	1975-1978	Double wall - cooled
29-32	H	III	981232	1967-1970	Double wall - cooled
33-34	F	III	950974	1969-1972	Double wall - cooled
35-37	H	III	951463 (74-1-a)	1974-1977	Double wall - cooled
38-43	H	III	951618 (76-8-a)	1976-1980	Double wall - cooled
44-47	F	III	951747 (77-13-d)	1977-1980	Double wall - cooled
48-51	H	III	951828 (78-18-b)	1978-1981	Double wall - cooled

* Tanks 32 and 35 have removable, roof-supported cooling coils. Tanks 30, 33, and 34 have bottom-supported deployable cooling coils. Tanks 29 and 31 have some deployable and some close-packed cooling assemblies, all bottom supported. All other cooled tanks have permanently installed cooling coils, roof-supported in Types I and II and bottom-supported in Type III tanks.

Inner wall (at column)	
Upper band	1/2 inch
Lower band	5/8 inch
Lower knuckle	
Outer	7/8 inch 1 inch in Tanks 29 through 32 only
Inner (at column)	5/8 inch

Tanks built before 1974 were made of hot rolled ASTM A516-Grade 70 steel. All later tanks are fabricated with equivalent steels (either A516-Grade 70 or A537-Class I) with the added specification that the plates be supplied in the normalized condition. The normalizing heat treatment (similar to annealing) serves to optimize notch toughness of the plates and hence resistance to brittle fracture of vessels fabricated from them. See Appendix B.

Each primary tank sits on an 8-inch bed of insulating concrete within a secondary carbon steel containment vessel. The concrete bed is grooved radially so that ventilating air can flow from the inner annulus to the outer annulus. Liquid would move through the slots, and any leak from the tank bottom or center annulus wall would probably be detected at the outer annulus.

The secondary vessel is 5 ft larger in diameter than the primary vessel, with an outer annulus 2-1/2 ft wide. The secondary vessel is made of 3/8-inch steel throughout. Its sidewalls rise to the full height of the primary tank. The nested two-vessel assembly is surrounded by a cylindrical reinforced concrete enclosure with a 30-inch wall. The enclosure has a 48-inch flat reinforced concrete roof which is supported by the concrete wall and also a central column that fits within the inner cylinder of the secondary vessel.

Because of a high water table, the tanks in H Area are elevated above natural grade and surrounded with mounded earth. The water table in F Area was lower than at H Area, and the tanks in F Area were installed with their tops flush with natural grade. Because the tanks are above predicted water tables, only standard waterproofing was applied to the concrete enclosure. The highest measured water table is at least 3 ft below the tank bottoms. The 48-inch concrete covers for these tanks reduce the radiation field above any of them with high-heat waste in the tank to less than the amount permissible for continuous occupancy by operating personnel, hence no earth overburden is required.

Cooling

Type III tanks constructed after 1975 are provided with permanently installed, bottom-supported, vertical coils on 3-foot triangular centers. Unlike Type I and II tanks, the Type III tanks do not have horizontal coils near the tank bottom; in these tanks the bottoms are cooled by forced air flow underneath. The nominal heat removal capacity of these coils is 6×10^6 Btu/hr. Uniformly distributed cooling coils were selected for these tanks to make them suitable for storing all types of wastes.

Bundles of closely spaced coils are satisfactory for cooling liquid wastes, including fresh waste with maximum heat output, because convection circulates the liquid and thereby carries the heat from remote regions of the tank to the widely spaced bundles. However, in tanks receiving evaporator concentrate, cooling surfaces soon become encrusted with crystallized waste salts, and all heat must flow through the deposited salt by conduction, which is a relatively inefficient process. Hence, the coils must be distributed as widely as practical throughout the tank, so that a maximum volume of solid salt can be accumulated before the salt thickness on any one coil becomes too great to pass its share of the heat to be dissipated.

In Tanks 32 and 35, unsaturated liquid waste is cooled by cooling-coil bundles (Figure A-1) that are suspended in the tank through risers in the roof. A maximum of 10 cooling units can be inserted in each tank. Each unit has a heat removal capacity of 600,000 Btu/hr, and there are five in each tank.

Because installation of uniformly distributed cooling coils in Type III tanks already in service is not practical, those now in concentrate service (Tanks 29, 31, 33, and 34) are being provided with deployable coolers, which are inserted through the roof ports and then expanded horizontally to distribute their cooling surfaces more widely than is the case with the consolidated bundles. Two models of deployable coolers are in use. The early model, of which four units are installed in Tank 33 and seven in Tank 34, has 11 double-pipe (hairpin) elements in a conical configuration with a base diameter of 24 ft. The latest model deploys at both top and bottom into a cylindrical configuration 16 ft in diameter, with 20 single-pipe elements. Figure A-1 shows the basic configurations of the three types of insertable coolers. Both deployable models are nominally 30 ft high, although most units have somewhat shortened elements in order to clear the salt layers already on the bottoms of the tanks at the time of installation. Fifteen cylindrical units are currently in service in Tanks 29(4), 30(2), 31(2), 33(4), and 34(3). Three units were originally installed in Tank 31, but one unit is not operable. Three additional units are funded for installation in Tank 30.

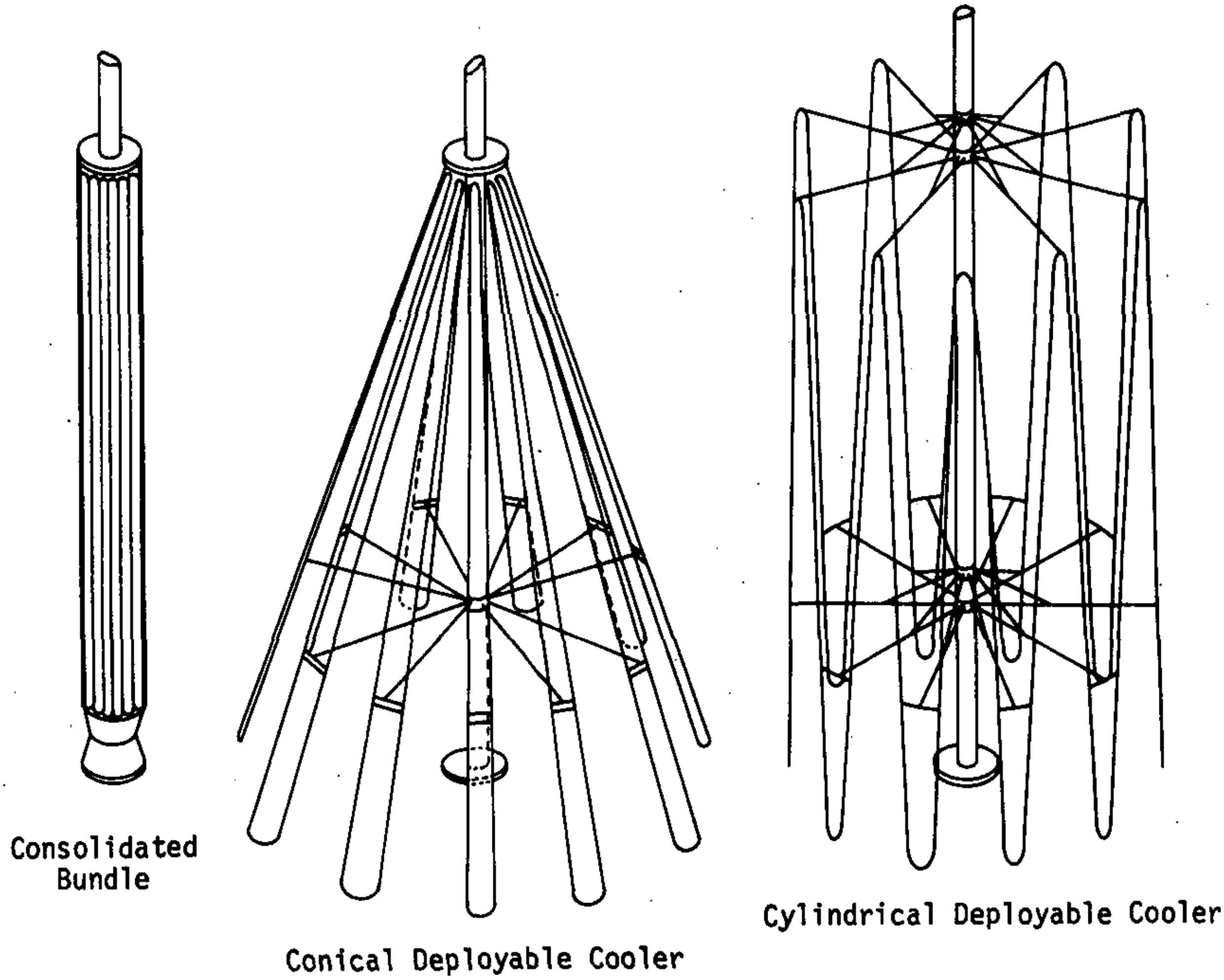

FIGURE A-1. Insertable Coolers for Type III Tanks 29 through 35

In addition to the deployable coolers cited above, Tanks 29 and 31 each have five close-packed bundles (similar to Figure A-1) that were installed before development of the deployable coolers.

Construction Inspection and Testing

These waste tanks were designed and constructed under increasingly rigorous Quality Assurance plans as requested by DOE. Design of the vessels according to the ASME Code, Section VIII for the construction of pressure vessels ensures that the mechanical requirements are satisfied.

All butt welds on the primary tanks, except welds on the horizontal roof surface, and all butt welds on the secondary tanks joining bottom plates, knuckle plates, and the lowest courses of center-column and outer-wall plates are radiographically inspected. Defects are corrected, and then they are rechecked radiographically. Beginning with the FY-1974 tanks, all plate welds in the secondary tanks are radiographically inspected. All spots on the inside or outside of the primary tanks or the inside of the secondary tanks, where clips or lugs were removed or where other excisions were made, are examined by magnetic particle or liquid penetrant techniques. Any defects are repaired. All butt welds on the secondary tanks are vacuum leak-tested. All welds in the bottom assemblies of the primary tanks, including knuckle rings and lowest course welds, are vacuum leak-tested before each bottom assembly is lowered into final position; these welds are then tested a second time after the stress-relieving operation. A full hydrostatic test, consisting of filling each primary tank with water to a depth of 32 ft and allowing it to stand 48 hours, is conducted after stress relieving. Circumferential welds in the pipe loops of the cooling coils are radiographed. The assembled piping is tested hydrostatically to 500 psi and halide leak-tested at 30 psi.

Tank surfaces are sandblasted to remove mill scale and facilitate inspection for inclusions and laminations. Plate edges are ground clean and smooth to inspect for end laps.

Surface Protection

No special surface protection treatment was applied. Rusting of annulus chamber surfaces exposed to air is controlled by maintaining the temperature of the air a few degrees above the dew point. Keeping the tank warm also inhibits interior rusting prior to its being placed in service.

Stress Relieving

The primary tank is stress-relieved in place after all burning, cutting, welding, and other high-temperature work below the liquid fill line has been completed. Full stress relief at 1100°F is accomplished in accordance with the general requirements of the ASME Boiler and Pressure Vessel code.

Tank Instrumentation

The top openings into the Type III tanks and annular spaces are closed with stepped concrete plugs (lead plugs in a few cases), and the openings are used for instrumentation, cooling units, or ventilation system connections. The principal instrumentation provided for each tank consists of:

- Liquid Level. The amount of liquid waste is determined by two different systems in each tank. One system uses a conductivity probe on the end of a tape reeled in or out by a motor drive, with both local and remote readout in the Control Room. Hand-held steel tapes serve as a backup system.

  For Tanks 29 through 34, four stationary conductivity probes are provided, one in each quadrant, for determining the presence of liquid in the annulus. Three of the probes are single-point devices, and the fourth is a multipoint probe that can obtain an approximate determination of the liquid level in the annulus as well as the indication of leakage. A pneumatic dip-tube system is also provided. Later Type III tanks have a single-point probe in each quadrant and a single-point probe in the center column annulus. Evidence of leakage into annulus, as well as tank high- and low-liquid level in any of these waste tanks, is signaled to the tank farm control house.

- Temperature. Temperature measurements are obtained from thermocouples located in and around the waste tanks. See Tables A-2 and A-3 for locations and alarm settings. Thermocouples are grouped and referenced to alarm modules according to tank service and thermocouple location. This arrangement provides maximum ease and flexibility in changing alarm settings.

  A stainless steel thermowell is installed in each of four tank-top plugs, spaced 90° apart, on each Type III waste tank. Seven thermocouples are installed in each thermowell spaced from 1 inch from the bottom of the tank to about 26 feet from the bottom.

  Temperatures are recorded in the control house, and recorders are equipped with high-temperature alarms.

TABLE A-2

Currently Specified Thermocouple Locations

Location	Thermocouples Per Tank
Annulus air in	1
Annulus air out	1
Purge vent	1
Purge condenser air out	1
Purge condenser CW out	0
Cooling water supply	1
Cooling water return	1
Tank contents (Risers D1 through D4)	21-28
Primary liner sidewalls	6
Primary liner knuckleplate	4
Primary liner bottom	12
Secondary liner bottom	2
Working slab bottom	2
	60

TABLE A-3

Temperature Alarm Set-Points by Tank Service or Contents

Thermocouple Location or Service	Alarm Temperature, °C
Cooling water supply Purge condenser cooling water outlet	<5
Cooling water return	>80
Lower primary liner knuckleplates	<21
HLW, LLW, and sludge tank vents HLW and LLW contents 10 ft and above HLW and LLW primary sidewalls 10 ft and above	>65
HLW and LLW contents below 10 ft	>135
HLW and LLW primary sidewalls below 10 ft HLW and LLW primary bottoms	>180
Salt and feed tank vents	>90
Salt tank contents Salt tank primary sidewalls and bottoms	>100
Feed tank contents Feed tank primary sidewalls and bottoms	>90
Sludge tank contents Sludge tank primary sidewalls and bottoms	>135

- Pressure and Flow. The water supply line to the cooling units for each tank is equipped with a pressure gage, and connections for a portable flowmeter are provided. Each cooler is equipped with a pressure relief valve on the outlet piping and a pressure gage on the inlet. In the tank vapor space ventilation system, tank static pressure, pressure downstream of the filters, and differential pressure across the demister can be measured for each tank. Differential pressure switches are installed to signal vent exhauster failures and plugged filters.

Ventilation

The ventilation systems for Type III primary tanks are negative-pressure systems designed for purging the interior volume at a rate in excess of 100 cfm. In a typical installation, air enters through a HEPA filter and is conducted by a 4-inch pipe through the roof into the waste storage space. Air leaves the storage space by way of a 12-inch riser pipe positioned across the tank from the inlet. The exhaust air first passes through a demister in the riser, which intercepts droplets and returns them to the tank. Then the air passes through a condenser to extract potentially radioactive moisture, through a heater to raise the air temperature above its dew point (to prevent water vapor condensing on the HEPA filters), and through a HEPA filter to remove solid particles. The air is finally discharged to the atmosphere through an exhaust blower. Tanks 35 through 37 (and all future tanks) have systems that continuously monitor the radioactivity level and hydrogen concentration in the tank purge exhaust air.

The ventilation and dehumidification systems for Type III tank annuli differ from those installed in annuli Types I and II tanks in that, in addition to the warmed air flow directly into the outer annulus, approximately 1000 cfm of air is drawn through the inner annulus, passes beneath the primary tank through the radial grooves in the concrete base slab, and exhausts into the outer annulus. Beginning with Tanks 35 through 37, the annulus ventilation system will have a capacity of about 8000 cfm, up to about half of which can be passed through the inner annulus and beneath the primary tank. The increased flow is to aid in cooling the tank bottom. All of the Type III annuli are ventilated under negative pressure by means of exhausters (Type I and II annuli operate under positive pressure). Tanks 35 through 37 (and later tanks) also have radiation detectors to monitor the concentration of radioactivity continuously in the annulus exhaust.

Waste Inlet and Outlet Piping

One 3-inch-diameter, Schedule 40, stainless steel waste transfer pipeline is connected to each tank from diversion boxes except Tank 43H and Tank 26F, which have two. The pair of transfer lines running from the diversion box to the encasement wall of each tank is enclosed in an 8-inch-diameter, Schedule 20, carbon steel pipe jacket. The jacket goes through the tank encasement wall. The slope of the waste transfer lines is such that they are free draining (without pockets). The jacket piping drains to a leak detection box fitted with a probe for detecting liquid.

In the first six Type III tanks (29 through 34), two 3-inch-diameter inlet lines bridge the tank annulus within a jacket. The jacket tube consists of two pieces, a 10-inch-diameter, Schedule 20, carbon steel pipe that is telescoped into a 12-inch-diameter, Schedule 40, carbon steel pipe. The outer end of that jacket assembly is embedded in the tank's concrete encasement, and the joint between the two telescoped sleeves is sealed with asbestos packing that can slip slightly to allow for thermal expansion. The jacket pipe and the two inlet lines are welded individually to the outside surface of the tank.

In the FY-1974 and subsequent Type III tanks, the packed telescoping joint in the line jackets is eliminated, and the jacket is continuous to the tank interior, being seal welded to the primary tank upper knuckle. This provides greater jacket integrity and permits hydrostatic testing of the jacket. To accommodate expansion, the jacket passes through a slightly larger pipe sleeve welded to the secondary liner and embedded in the concrete vault wall. The annulus between the jacket and the sleeve is packed with asbestos to seal off the tank annular space from the tank exterior.

The two inlet lines enter the primary tank through the top knuckle; each terminates in a connector flange a few feet inside the tank, about one foot above the tank's normal fill line, and under a tank top riser. Thermal expansion of the waste inlet lines, outside the primary tank, is accommodated by free space in the jacket and bends in the lines at a short distance from the tank. A steam jet can be connected (within the tank) to either of the inlet lines to permit withdrawal of supernate liquid waste from the tank.

Each tank is also equipped with a stubbed-off spare inlet line for unprocessed waste and an inlet and outlet line for the recirculating waste concentrate loop. The spare inlet line and the concentrate lines are 2-inch-diameter stainless steel pipe.

The design for all of these is similar to that for unprocessed waste transfer lines described above, except that smaller jacket pipes are used (6-inch and 8-inch diameter).

The lines for unprocessed waste (fresh or aged) and for the concentrate inlet and outlet lines each terminate in connector flanges within the tank, under tank risers. Service nozzles for steam or air and flush water, respectively, are mounted in the same supporting framework. Adapter assemblies can be inserted into a tank through a riser to make connections for appliances such as waste inlet downcomers, steam eductors and waste-out transfers, and concentrate inlet drop valves. The connections are gasketed flanges that are designed to be tightened by applying torque to screw stems which are accessible in the riser, and which activate clamping mechanisms on the flanges.

Leak Detection

The primary means for detecting leaks from the primary vessels is the same for all double-walled tanks: instrumented and visual surveillance for liquid in the secondary pan or liner under the annular space between the free-standing primary tank and the secondary vessel. Conductivity probes, supplemented by pneumatic bubbler tubes (dip tubes), are installed in each tank annulus to provide automatic early warning if liquid accumulates in the annulus. Evidence of leakage into the annulus, as well as changing liquid level in any of these waste tanks, is signaled to the tank farm control house. Four access risers in each tank annulus permit direct visual inspection of limited regions of the annulus pan. An optical periscope and direct photography are also used for annulus inspection. Beginning with the FY-1974 tanks (Tanks 35 through 37), Type III tanks are provided with 14 similar annulus inspection ports (plus the four large risers); these will permit inspection by periscope and direct photography of 100% of the primary wall outer surface. The methods for inspection and the significant results to date are summarized in Section II-A of ERDA-1537.

Beginning with the waste tanks constructed under FY-1975 Project 75-1-a, an additional improvement in leak detection capability is provided (Figure 3-3) which permits verification of the integrity of the secondary tank. A grid of interconnected radial channels is formed on the inside of the concrete base slab on which the secondary tank rests. The channels are sloped to drain through a collection pipe to a sump outside the concrete enclosure around the tanks. An access pipe rises to grade from the sump to allow for liquid measurement, sampling, and pumpout of collected liquid. This system is similar to that under the single-wall tanks

(Type IV). No such system was included in the Type I and II tanks or the early Type III tanks.

A gamma monitoring tube network was installed beneath the tank foundation slab of Tanks 36 and 37 (FY-1974, Project 74-1-a) because no leak detection gridwork (as planned for all future Type III tanks) was included in this project. A gamma monitoring tube network was not installed under Tank 35 because the tank was urgently needed for fresh waste service, and the installation of monitoring tubes would have significantly delayed availability of the tank. The gamma monitoring system is a series of 3-inch steel tubes, welded smooth, and lined with polyethylene. At least twice a year, a gamma radiation detector is inserted into the liner to monitor for leakage outside the secondary container.